Use of Low Cost Personal Robots for the Encouragement, Demonstration and Assessment of Physical Activities

Thitipong Nandhabiwat
M.Sc. (Information Science), University of Pittsburgh, USA
B.Sc. (Computer Science), University of Waikato, NZ

Murdoch UNIVERSITY

This thesis is presented for the degree of
Doctor of Information Technology of Murdoch University
January 2011

DECLARATION

I declare that this thesis is my own account of my research and contains as its main content work, which has not previously been submitted for a degree at any tertiary education institution. To the best of my knowledge the thesis contains no material previously published or written by another person, except where due reference has been made in the text.

_____

Thitipong Nandhabiwat

ABSTRACT

One of the biggest challenges today is the issue of an overweight population. The issue is expected to impose tremendous pressure on the economic and financial health of a nation. The problem is now affecting developed and developing countries alike. In countries such as the USA and Australia, it has been reported that over 50% of the adult population are now either overweight or obese and the situation is expected to get worse. In developing countries like China, India and Thailand, similar problem is also emerging and in particular among the younger generation who has been exposed to wide varieties of processed or “junk” food. Apart from dietary and genetic reasons, the root cause of the weight problem is *lacking of physical activities*. With the increasing choices of indoor entertainment and transport facilities, in particular private cars, adult and children are now on average burning less daily calories while consuming more food loaded with high levels of sugar and fat. One way to combat the issue is to encourage more physical activities through games or exercises. However, this could be a two-edged sword as injuries have been reported due to inappropriate practices of exercises such as yoga without the advice of formal trainers or instructors. Hence, it is the aim of this study to investigate and develop low cost personal robots for the encouragement, demonstration and assessment of physical activities, with an objective to improve the overall health of the population. Most robotic researches so far have yet to focus on the low-cost off-the-shelf robots. This research is therefore one of the few that focuses on this category of robots. This study also investigates the opportunities and potential with the low-cost off-the-shelf robots and how to develop them beyond their default

capability. This research has illustrated the feasibility of using low cost personal robots as a supplement to help or assist people of all ages in various kinds of physical exercises during their leisure time in a home environment. In this study, Thai school children have been motivated to learn or practice traditional Thai dances with the robots. This is not just for the sake of physical activities, but it also helps to preserve the culture and traditions among the future generation in Thailand.

The initial phase of the research has been a literature review on the backgrounds of robots, robotic applications, and human-robot interaction (HRI) as an emerged discipline. The thesis also describes two low cost robots, the WowWee Robosapien Media and the Speecys SPC-101C, used in this research. The research has demonstrated on their use as a trainer for the purposes of education, entertainment and training. Four categories of routines including Thai dance, yoga, cheerleading dance, and exercises for the elderly have been used as examples of physical exercises. Discussion on dance robots, entertainment robots and Thai dances have also been covered in this thesis.

Another finding of the research is a demonstration of the assessment of a human subject's movements by a robot. While most people are trained or learn from human trainers, this approach has its limitations due to cost and the number of trainees at any one time. While it is possible to learn from media such as television, Internet, CD or DVD, the trainees will not be able to get any feedback or assistance and this has been the main cause of the injuries. The study proves that a robot is capable to provide demonstration in three dimension as well as providing feedback, it can also be used to assess the movements of the human subject through image or video

processing and measurement. In this project, customized software has been developed to control the robot and two web cameras have been used to provide monitoring and capturing of the human movements for assessment and feedback.

Outcome from this study has demonstrated that the two low-cost off-the-shelf humanoid robots used in this research are capable of assisting and enhancing the performance, enjoyment, and motivation of the participants through interactive activities with the robots. The performance of the participants attended the training session was positively improved through training and the improvement is demonstrated through pre-test and post-test assessments. In this thesis, detailed results of the study are reported and future research works are also discussed.

ACKNOWLEDGEMENT

First and foremost, I would like to humbly give my thanks and gratitude to the King of Thailand, His Majesty King Bhumibhol Adulyadej for always bestowing on the Thai people countless precious lifelong thoughts and life living lessons. It is my utmost honor and privilege to serve under Your Royal Highness's Throne and the country. I pledge myself to give all my devotion to serve society for the betterment of the country.

Second of all, I have to thank my dad and mom for the greatest support and understanding in every aspect of my life. Also, thanks to the invaluable support from my wife, Napapan Nandhabiwat and my son, Dhubdheb Nandhabiwat. Without the inspiration from all of you, I would not have had made it.

Very special thanks and gratitude are wholeheartedly dedicated to my principal supervisor, Associate Professor Dr. Lance C.C. Fung, for his magnificent supervision, advice, support and guidance. To me, you are the greatest supervisor I have ever known. You are more than just a supervisor and you are the world of giving. You have taught me so much not only through academic lessons, but also through living life lessons. Saying thank you to you in a million times will never suffice. Once again thank you and thank you from the bottom of my heart. Thank you also to my co-supervisor, Associate Professor Dr. Kevin Wong, for your kind supervision and suggestions.

I wish to express my sincere thanks and gratitude to the President of Rangsit University, Dr. Arthit Ourairat, for his encouragement and support given to me in pursuit of this doctorate degree.

Last but not the least, I'd like to thank the faculty members at the University of Pittsburgh and the University of Waikato for preparing me for life long learning in the real world, and for provided me with invaluable academic experience and training.

LIST OF PUBLICATIONS

[1] C. C. Fung, T. Nandhabiwat, A. Depickere, and K. Malaivongs. "Thai Dance Training-Assist Robot," in the *Proceeding of the 8th Electrical Engineering and Computing Symposium (PEECS 2007)*, Western Australia: Curtin University of Technology, 2007, pp. 108-111.

[2] C. C. Fung, T. Nandhabiwat, and A. Depickere. "iThaiSTAR – a Low-Cost Humanoid Robot for Entertainment and Teaching Thai Dances," in the *Lecture Notes in Computer Science*, *Technologies for E-Learning and Digital Entertainment*, Springer Berlin / Heidelberg, Vol. 5093/2008, pp. 99-106.

[3] C. C. Fung and T. Nandhabiwat. "Comparing Two Off-the-shelf Robots for the Demonstration of Thai Folk Dances – an Initial Study," in the *Proceedings of the International Conference on Advances in Computer Entertainment Technology 2008 (ACE2008)*,Yokohama, Japan, 2008, pp. 309-312.

[4] T. Nandhabiwat and C. C. Fung. "Future E-Business Opportunities with Companion Robots," in the *Proceedings of the 7th International Conference on e-Business 2008 (INCEB2008)*, Thailand: Rangsit University, 2008, pp. 192-198.

[5] T. Nandhabiwat and C. C. Fung. "An Analysis of Two Low Cost Humanoid Robots for the Demonstration of Thai Folk Dances," in the *Proceeding of the 9th Electrical Engineering and Computing Symposium (PEECS 2008)*, Western Australia: University of Western Australia, 2008, pp. 171-175.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

2D	2 Dimensional
3D	3 Dimensional
AC/DC	Alternate Current / Direct Current
ASIMO	Advanced Step in Innovative Mobility
BEAR	Battlefield Extraction-Assist Robot
CLDC	Connected Limited Device Configuration
CCD	Charge Coupled Device
COM	Center of Mass
COP	Center of Projection
CT	Computed Tomography
DOF	Degrees of Freedom
GB	Gigabyte
HCI	Human-Computer Interaction
HOAP-3	Humanoid Open Architecture Platform-3
HRI	Human-Robot Interaction
HRP-2	Humanoid Robotics Project-2
IR	Infrared
iThaiSTAR	intelligent Thai Sanook Training-Assist Robot
iCHEER	intelligent Companion Humanoid Entertainment and Education Robot
J2ME	Java 2 Micro Edition
JRE	Java Runtime Environment

JSR	Java Specification Request
JTWI	Java Technology for the Wireless Industry
KMUTT	King Mongkut's University of Technology Thonburi
LCD	Liquid Crystal Display
MB	Megabyte
MERV	Miniature Emergency Response Vehicle
MIDP	Mobile Information Device Profile
MIT	Massachusetts Institute of Technology
MP3	MPEG-1 Audio Layer 3
MP4	Moving Picture Experts Group 4
MS DanceR	Mobile Smart Dance Robot
NASA	National Aeronautics and Space Administration
QRIO	Quest for Curiosity
RS	Robosapien
RSU	Rangsit University
R.U.R.	Rossum's Universal Robots
SD	Secure Digital
SDK	Software Development Kit
SDR	Sony Dream Robot
SE	Standard Edition
SPECT	Single-Photon Emission Computed Tomography
UV	Ultraviolet